Investigation of Secondary Processes by Interaction of Plasma Streams with Various Materials

R.T. KHAYDAROV
Scientific-Research Institute of Applied Physics at the National
University of Uzbekistan, Tashkent, Uzbekistan
Cable Address: 700174 Uzbekistan, Tashkent,
Vuzgorodok, Institute of Applied Physics
Telephone: 998-712-46-48-01
Facsimile: 998-71-144-32-53
E-mail: ragab@iaph.silk.org

At present, with increase of requirements in various energy sources, a power plant design for inertial fusion energy (IFE) is a very important problem. The experiments for this part have been carrying out for some main problems only. Main aspects of IFE problem are connected with the physics of proceed of fusion thermonuclear reaction in plasma with inertial keeping, with hydrodynamics and shock waves, with transportation process in dense plasma and interaction of the laser beam or bunch of charged particles with plasma and with a internal chamber wall.

Destruction of first wall by X rays and charged particles (products of expansion) are most significantly problems connected with IFE systems. In connection with this, several constructions of reactor volume were proposed [1]. These constructions are distinguished by interaction parameters of internal surface of first wall with X rays and charged particles.

Nowadays, because of using laser sources in the IFE program, the important issue is to study the influence of bars to charge composition and energy spectra of expansion plasma. The importance of this question is conditioned by the fact that in practically all laser ions sources the expansion of laser plasma, in that or other degree, is limited with different bars, frequently with diaphragms [2, 3].

In addition, the study of formation processes of bunch of multiply charged ions, in conditions of the interaction of plasma with secondary target, opens the possibility for plasma control parameters, charged and energy characteristics of ions bunches at same parameters of laser radiation [4, 5].

This work is devoted to study the charge and the energy spectra of multiply charged ions formed at the interaction of multiply charged laser produced plasma with surface of secondary target (Al). Experiments were carried out with the laser mass-spectrometer with a mass resolution of $m/\Delta m=100$ and with a flight distance of particles of 100 cm (Fig. 1). A neodymium laser with an irradiance power density $q=5\cdot10^{10}$ W/cm^2 was used. The characteristics of ion plasma bunch were measured in two cases: at the presence of the secondary target on its way and without. The secondary target intended for removing the ions to the laser mass-spectrometer is a disk for diameter 8 mm with a slot in the medium of size 0.4 mm and it was installed parallel to target surface.

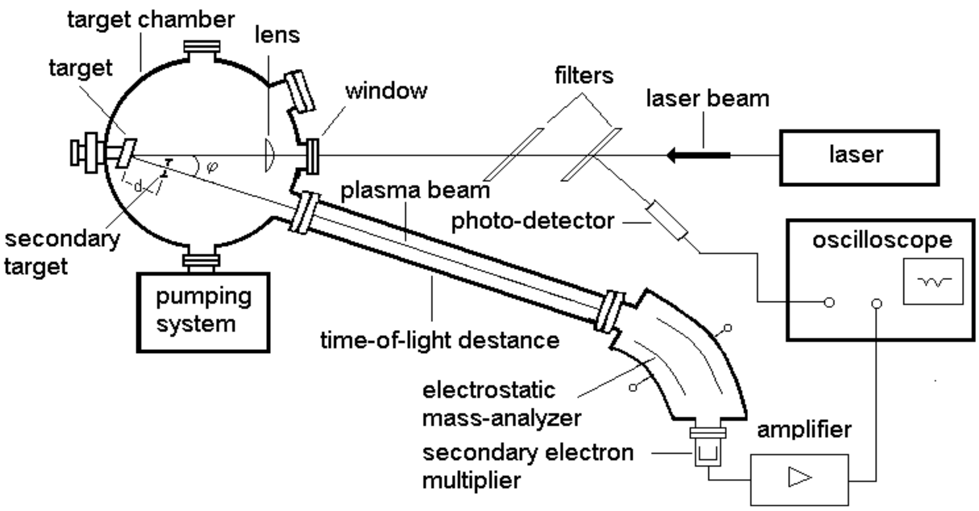
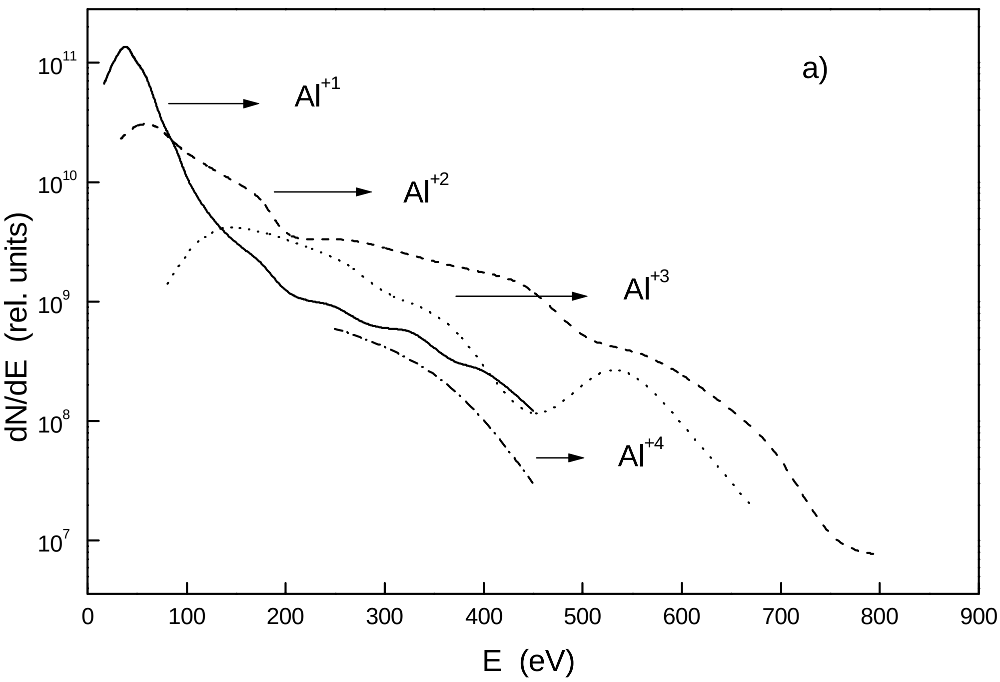


Figure 1: Experimental setup

The charge and energy spectra of plasma ions have been received in these cases (Fig. 2: a and b).



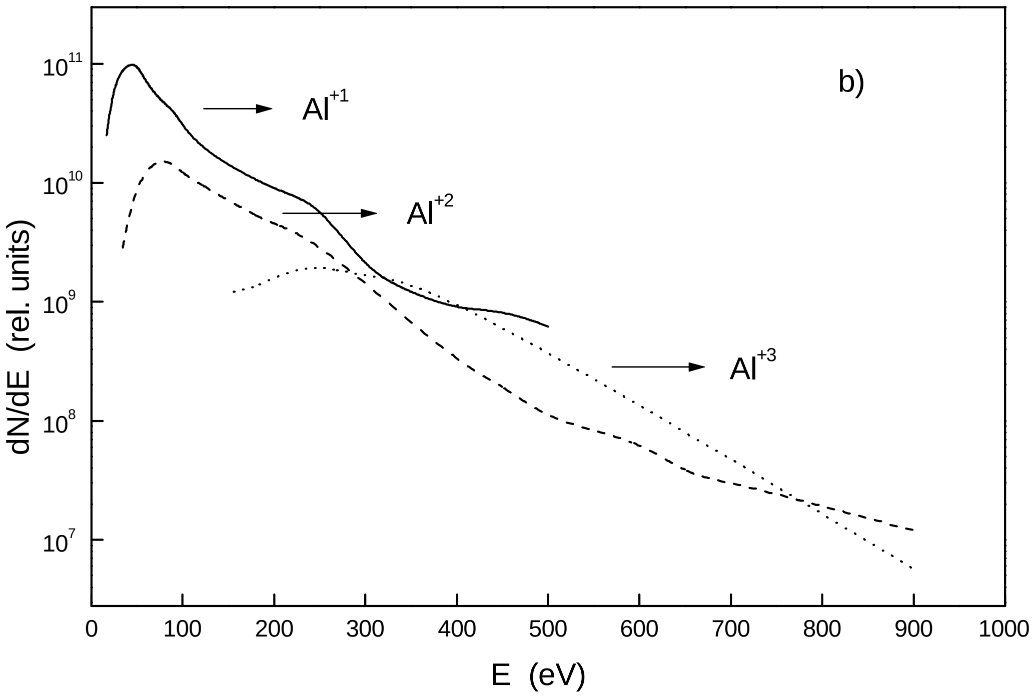


Figure 2. *Energy spectra of Al ions at presence of secondary target on its way (b) and without (a).*

The comparative data have shown that the interaction of plasma with the surface of the Al target, installed on the way of expansion of plasma, vastly changes the charge and energy spectra of multiply charged ions of the plasma.

It was experimentally found that these data depend on the distance between primary and secondary targets. The registered maximum charge multiples (Z_{max}) of multiply charged ions of the Al plasma without secondary target on its way and at presence one on the distance of 5 mm are 4 and 3 respectively (at $q=5\cdot10^{10}$ W/cm^2). The maximum energies (E_{max}) of this multiply charged ions in this case are ~ 800 eV and 900 eV respectively. The decreasing of the power density of the laser radiation from $q=5\cdot10^{10}$ W/cm^2 to $q=10^8$ W/cm^2 leads to the decreasing of Z_{max} and E_{max} with secondary target as well as without one. However, the nature of the change of the parameters of the ions bunch observed at $q=5\cdot10^{10}$ W/cm^2 is conserved. These experimental data show that recombination losses are higher in the presence of the secondary target than without one.

The increasing of the intensity of single charged ions Al^{1+} and the decreasing of the intensity of multiply charged ions Al^{2+} Al^{3+} at the interaction of laser plasma with the surface of the secondary target in comparison with the case without one are experimentally found. This effect intensifies the recombination processes on multiply charged Al ions and consequently leads to an increase of the amount of single charged ions Al^{1+}. The analysis of the energy spectra of the Al ions at various distances between the target and the secondary one confirms the experimentally observed effect, i.e. with increase of distance between the target and secondary one, energy spectra of multiply charge Al ions will be changed. This effect is shown in Fig. 3, where the intensity of highly charged ions (Z>1) of laser plasma scattering at the interaction with the secondary target (Fig. 3b) is vastly lower than the intensity of this plasma in the case without a secondary target (Fig. 3a).

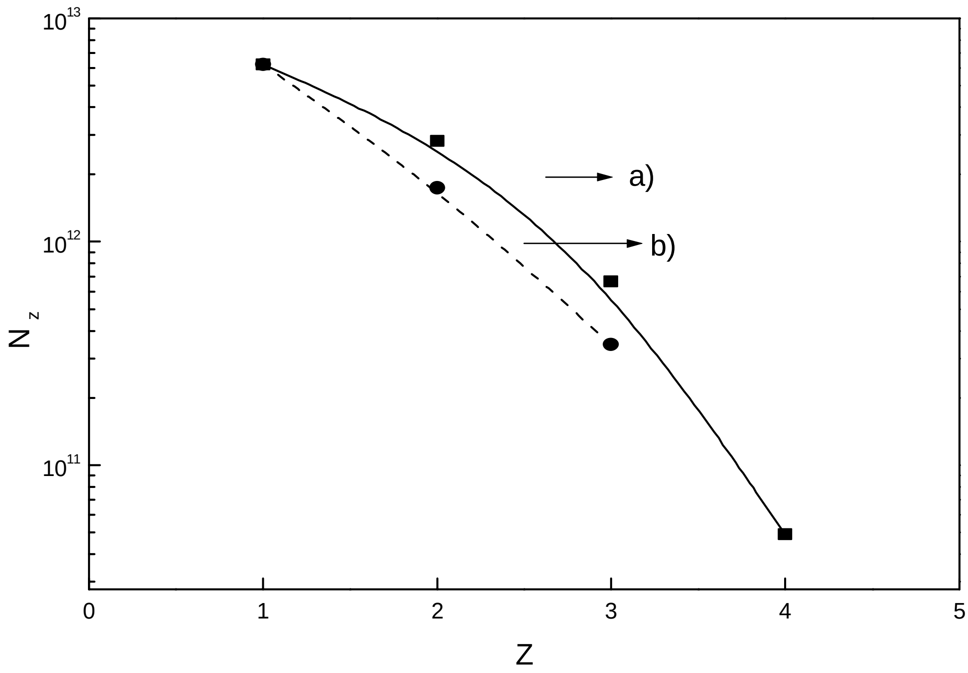


Fig. 3

Thus, the analysis of the experimentally obtained results for the study of the interaction of the laser plasma with the secondary target leads to the conclusion that this interaction may become a cause of the weakening of the ions flow density at the distance zone of the flight. The high energy ions flow density is weakened mostly.

Fruitful collaboration between the groups from the Institute of Applied Physics (Tashkent), the ITEP (Moscow), and the Gesellschaft für Schwerionenforschung–GSI (Darmstadt), is important for the success of the project as well as the exchange of scientists, scientific equipment and diagnostic systems.

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